

Tropical Cyclone and Hurricane Landfall Studies

Russell L. Elsberry
Department of Meteorology
Naval Postgraduate School
Monterey, CA 93943-5114
phone: (831) 656-2373 fax: (831) 656-3061 e-mail: elsberry@nps.navy.mil

Award Number: N0001403WR20147, N0001403WR20276

LONG-TERM GOALS

The long-term goal is to improve understanding of the tropical cyclone structure and motion throughout its evolution from formation, mature stage, and extratropical transition and thereby contribute to improved predictions of the tropical cyclone threat to the Fleet afloat and ashore.

OBJECTIVES

Working with a team of research collaborators, advance understanding of tropical cyclone during all stages using both observations and modeling approaches.

Working with the U.S. Weather Research Project (USWRP), provide scientific leadership to advance understanding and improve prediction of hurricanes threatening landfall on the United States.

APPROACH

Collaborative studies with present and past members of our research team have included studies of tropical cyclone formation (see separate reports by Patrick Harr and Kevin Cheung) and extratropical transition (reports by Harr and Elizabeth Ritchie, now at the University of New Mexico), and tropical cyclone motion prediction (with former team member Les Carr and Mark Boothe).

I have continued to serve as Science Coordinator for the USWRP Hurricane Landfall program and have produced a number of assessments of the status of our understanding and prediction of tropical cyclones throughout the globe. In pursuit of this objective, I also served as Director of the Firth International Workshop on Tropical Cyclones (IWTC-V) during December 2002.

WORK COMPLETED

The collaboration on extratropical transition with Patrick Harr has continued (see his report for details). I have submitted a comment (Elsberry 2003) on two recent articles in the *Monthly Weather Review* that purport to describe an extratropical transition of ex-hurricane Earl.

Another collaboration on tropical cyclone formation with Patrick Harr and Kevin Cheung (see separate reports) has continued both from an understanding and a building/testing of a prototype prediction system.

Report Documentation Page			Form Approved OMB No. 0704-0188		
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE 30 SEP 2003		2. REPORT TYPE		3. DATES COVERED 00-00-2003 to 00-00-2003	
4. TITLE AND SUBTITLE Tropical Cyclone and Hurricane Landfall Studies			5a. CONTRACT NUMBER		
			5b. GRANT NUMBER		
			5c. PROGRAM ELEMENT NUMBER		
6. AUTHOR(S)			5d. PROJECT NUMBER		
			5e. TASK NUMBER		
			5f. WORK UNIT NUMBER		
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Department of Meteorology, Naval Postgraduate School,, Monterey,, CA, 93943			8. PERFORMING ORGANIZATION REPORT NUMBER		
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)			10. SPONSOR/MONITOR'S ACRONYM(S)		
			11. SPONSOR/MONITOR'S REPORT NUMBER(S)		
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 5	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

Prior collaboration with Les Carr on the development of the Systematic Approach to tropical cyclone track forecasting has resulted in a book chapter (Elsberry and Carr 2002). Continuing collaboration on development of the Systematic Approach in the North Indian Ocean and Atlantic Ocean with Mark Boothe has been reported on in two conference presentations (Boothe, et al. 2003a; Boothe and Elsberry 2003b).

The USWRP Hurricane Landfall (HL) effort has produced an assessment of the hurricane landfall precipitation problem (Elsberry 2002a). A summary of the USWRP HL program was also presented to the WMO World Weather Research Program (Elsberry 2003d). In conjunction with the IWTC-V, a nearly 500-page workbook was edited and published as a World Meteorological Organization Technical Document WMO/TD No.1136 in hard copy and on a CD. I wrote the Topic 1 report on tropical cyclone structure and structure change in that workbook (Elsberry 2002b). I also wrote and/or edited the final report, which is WMO/TD No. 1165 (TMRP No. 68), including the preface, introduction, Topic 1 report, and an Appendix (with C. Velden). The Appendix was then submitted for publication (Elsberry and Velden 2003) in the *WMO Bulletin*.

RESULTS

Extratropical transition of tropical cyclones is a significant forecast challenge for Navy (and civilian) forecasters because of the threat to transiting ships and coastal bases. Under the leadership of Patrick Harr, our research team has contributed to understanding of extratropical transition via both observational and modeling studies (see the Harr and the Ritchie reports). A critical factor in the extratropical transition is the relative contributions of the midlatitude trough and the tropical cyclone (Klein et al. 2002). In some cases, the midlatitude trough is the dominant contributor. In other cases, the tropical cyclone position and structure is a dominant factor. When both circulations contribute in an optimum sense, a major extratropical cyclone results during the re-intensification stage. The modeling study by Ritchie and Elsberry (2003) clarifies the favorable and unfavorable geometrical relationships between the midlatitude trough position and the tropical cyclone position. Collaboration with Elizabeth Ritchie is continuing on modeling aspects and a Taiwan researcher (Stefano Liu) will continue the observational studies of western North Pacific extratropical transition.

One of the results from the Klein et al. (2002) study was that apparent extratropical transition cases exist in which the tropical cyclone is present but actually has no contribution to the extratropical cyclone development. This case is demonstrated by removing the tropical cyclone circulation from the model initial conditions and finding that the extratropical cyclogenesis occurs in the same locations and with the same amplitudes as in the control integration with the tropical cyclone present. This is the basis for the Comment (Elsberry 2003a) in relation to two papers describing a purported extratropical cyclogenesis of ex-hurricane Earl. As in Klein et al., the removal of the Earl remnants from the initial conditions does not change the prediction of an explosive extratropical cyclogenesis off the east coast of Canada. It is important that an accurate record of extratropical transition cases be established for research studies, and also that the archive of the National Hurricane Center be corrected to reflect a dissipation of ex-hurricane Earl and not an unreasonable northeastward track to the extratropical cyclone prediction. These were the purposes for submitting the Comment.

IMPACT/APPLICATIONS

The production of the IWTC-V workbook (WMO 2002) has provided an assessment of the progress in tropical cyclone research and forecasting over the past four years and the opportunities for research and

future requirements for forecasting. The final report for the IWTC-V (WMO 2003) summarizes the discussions and lists the recommendations for WMO programs/activities, for the research community, and for the forecaster community. In that sense, these WMO documents provide a global view of the status and requirements for research in tropical cyclones that supplements the USWRP documents produced in 2002 (e.g., Elsberry 2002). In particular, these documents provide a guideline for future research efforts.

TRANSITIONS

The extratropical transition results has been forwarded to the Joint Typhoon Warning Center (JTWC) and incorporated into their training materials.

RELATED PROJECTS

As indicated in the text above, the Naval Postgraduate School research team includes Patrick Harr, Kevin Cheung, and Mark Boothe. Collaboration with former team member Elizabeth Ritchie is continuing.

SUMMARY

Whereas the focus of our research team in the past has been on tropical cyclone motion understanding and improved track prediction at JTWC, our present focus is on formation and extratropical transition, because these stages in the tropical cyclone life cycle are also important to the Navy for protection of the fleet and possible tactical advantage. In addition, the early stage and extratropical transition stage are when the track prediction errors are largest, so improved understanding of those stages will improve the accuracy of the five-day track forecasts that are required by the Navy.

REFERENCES

Klein, P. M., P. A. Harr, and R. L. Elsberry, 2002: Extratropical transition of western North Pacific tropical cyclones: Midlatitude and tropical cyclone contributions to re-intensification. *Monthly Weather Review*, **130**, 2240-2259.

PUBLICATIONS:

Elsberry, R. L., 2002a: Predicting hurricane landfall precipitation. *Bulletin American Meteorological Society*, **83**, 1333-1339.

Elsberry, R. L., 2002b: Tropical cyclone structure and structure change. Topic 1 report, World Meteorological Organization WMO/TD No.1136.

Elsberry, R. L., 2003a: Comments on “The influence of the downstream state on extratropical transition: Hurricane Earl (1998) case study,” and “A study of the extratropical re-intensification of former Hurricane Earl using Canadian Meteorological Centre regional analyses and ensemble forecasts.” *Monthly Weather Review* (submitted).

- Elsberry, R. L., 2003b: Tropical cyclone structure and structure change. Chap. 4, Proceedings of the fifth International Workshop on Tropical Cyclones (IWTC-V), World Meteorological Organization WMO/TC No.1165 (in press).
- Elsberry, R. L., and L.E. Carr III, 2002: Systematic Approach for tropical cyclone track forecasting with dynamical model consensus. In *East Asia and Western Pacific Meteorology and Climate*, C.-P. Chang, G. Wu, B. Jou, and C. Y. Lam, Eds., World Scientific Series on Meteorology of East Asia, vol. 1, Imperial College Press (London), 228-236.
- Elsberry, R. L., and C. Velden, 2003: A survey of tropical cyclone forecast center present uses and needs of satellite data. *World Meteorological Organization Bulletin*, **52**, 258-264.
- Ritchie, E. A., and R. L. Elsberry, 2003: Simulations of the extratropical transition of tropical cyclones: Contributions by midlatitude, upper-level trough. *Monthly Weather Review*, **131**, 2112-2128.
- WMO, 2002: Topic chairman and rapporteur reports of the fifth WMO International Workshop on Tropical Cyclones (IWTC-V). R. L. Elsberry, Ed., World Meteorological Organization, WMO/TD No. 1136, Geneva, Switzerland, ~ 500 pp.
- WMO, 2003: Proceedings of the fifth International Workshop on Tropical Cyclones (IWTC-V), R. L. Elsberry, Ed., World Meteorological Organization, WMO TD No. 1165 (in press).

CONFERENCE PRESENTATIONS:

- Boothe, M. A., R. L. Elsberry, and L. Salvador, 2003a: Beta test of a prototype dynamical model track prediction evaluation system model for the Atlantic and eastern Pacific. Presented at 2003 Interdepartmental Hurricane Conference.
- Boothe, M. A., and R. L. Elsberry, 2003b: Meteorological and Model Traits knowledge bases for North Indian Ocean tropical cyclone track forecasting. Presented at 2003 Tropical Cyclone Conference, Monterey, CA, 19-21 February.
- Harr, P. A., and R. L. Elsberry, 2003: Prediction of intraseasonal tropical cyclone activity over the western North Pacific. Presented at 2003 Tropical Cyclone Conference, Monterey, CA 19-21 February.